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SHELF LIFE OF TOMATOES AS AFFECTED BY A POST HARVEST TREATMENT AND STORAGE CONDITIONS

by

Abdul R. Rahman

Glenn Schafer

Thomas J. DiNicola

Donald E. Westcott

Project references: 728012.12

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Laboratory tests were conducted to determine the effect of treating tomatoes with an aqueous solution of chlorine dioxide as well as storage under a low oxygen (4-5%) controlled atmosphere system on their overall quality and shelf life. Tomatoes treated with chlorine dioxide and then stored under low oxygen at 50-55°F. exhibited the highest edible yield at the end of 6 weeks storage. Color and flavor of tomatoes stored under low oxygen regardless of the chlorine dioxide treatment at 50-55°F as evaluated by a technological panel were significantly preferred to those stored under normal atmosphere at similar temperatures. Time of storage was the only factor affecting the texture of tomatoes.

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FOREWORD

Fresh produce such as lettuce and tomatoes have been reported to undergo spoilage during shipping to military installations overseas. Causes for the spoilage included slime, decay, mold and discoloration. An investigation has been conducted on the effect of a low oxygen controlled atmosphere system used for the transportation of fresh produce in refrigerated containers on the shelf life and overall quality of tomatoes.

This work was performed under Production Engineering Project 728012.12.

The authors wish to acknowledge the assistance of the Oxytrol Corporation, Salinas, California, for providing the controlled atmosphere containers and the nitrogen gas. Acknowledgement is also due to Mrs. M. Driver for the color determination of tomatoes and to Mr. O. Stark for his assistance in the gas analysis.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ABSTRACT

Laboratory tests were conducted to determine the effect of treating tomatoes with an aqueous solution of chlorine dioxide as well as storage under a low oxygen (4-5%) controlled atmosphere system on their overall quality and shelf life. Tomatoes treated with chlorine dioxide and then stored under low oxygen at 50-55°F. exhibited the highest edible yield at the end of 6 weeks storage. Color and flavor of tomatoes stored under low oxygen regardless of the chlorine dioxide treatment at 50-55°F. as evaluated by a technological panel were significantly preferred to those stored under normal atmosphere at similar temperatures. Time of storage was the only factor affecting the texture of tomatoes.

INTRODUCTION

The supply of fresh produce to the Military Services overseas represents a sizable investment particularly when one considers not only the acquisition cost but also the cost of inspection, transportation, cold storage and distribution to the customer. From the standpoint of cost of perishables, tomatoes are second to lettuce in value. Experience has shown that current handling practices do not insure that tomatoes arriving overseas will meet consumer standards. Spoilage of tomatoes is a continuing problem, although significant improvements have been made in packaging and refrigeration.

Guidelines for the handling of tomatoes stipulates that an intransit temperature of 55°F. should be maintained (anonymous 1968). Tomatoes are normally purchased without regard to place of origin, post harvest treatment, packaging, handling practices or holding conditions. The lack of uniform practices makes it impossible to predict the loss of any one shipment; however, losses as high as 70 percent have been reported. The domestic market operates on a shelf life of 1-3 weeks, whereas shipping overseas may require a shelf life of 5-8 weeks. Several researchers have indicated that storage temperature is a significant factor affecting the shelf life of tomatoes. Parson (1959) conducted studies abroad a Navy reefer ship and concluded that mature green tomatoes stored at 58°F. until firm ripe and then transferred to 33-35°F. gave the best results. Gradual ripening of mature green tomatoes at 55°F. and then storage at 32°F. results in prolonging their shelf life (Heiligman).

Preliminary work at Natick Laboratories on storage of mature green tomatoes at 40°F. indicated that after 3-4 weeks insignificant color change took place especially at the stem end and in the interior; in addition fungi infections were developed. Mature green tomatoes stored below 50°F. are more susceptible to fungi infections - (McCullock 1952, Butler 1960).

Tolle (1969) indicated that under hypobaric storage of tomatoes (low pressure) where the oxygen content ranged from 5-21 percent, red color development of tomatoes was minimized at the 5 percent level. This system, in principle, is equivalent to other CA (controlled atmosphere) systems whereby the O_2 level is controlled. However, it seems impractical to use such low pressure systems on a commercial basis using 30-40 ft. vans due to the atmospheric pressure exerted on the walls of the vans. This would require an extremely strong structure to be able to withstand such external pressure.

Effects of pre-and post-harvest treatments such as chemical, packaging and atmosphere control on the storage of fresh fruits and vegetables have been investigated by several reserachers (Salunkhe 1960, El-Mansy 1968, Watada 1964, Singh 1970). In addition, considerable research has been conducted specifically on tomato storage requirements (Magoon 1968, McCulloch 1968). Hall (1963) described the chemical and physical changes (color, firmness, placental breakdown) that take place during the storage of tomatoes.

The Oxytrol Corporation indicated that their system of controlled atmosphere would significantly extend the shelf life of tomatoes. Since previous studies Rahman (1970) determined that controlled atmosphere extended the shelf life of lettuce, it was logical to conduct a laboratory test on the effect of low oxygen (approximately 5 percent) and very low carbon dioxide (below 1 percent on the shelf life of tomatoes.

EXPERIMENTAL PROCEDURES

Three experiments using different crops of tomatoes were conducted during the course of this study. Specific lots of tomatoes were stored in 72x32x89-inch containers using the Oxytrol* system, a complete self-contained atmosphere control system designed to be used as an adjunct to normal refrigeration equipment in conventional transport vehicles. These containers are designed for shipment or fixed storage of perishable commodities under low oxygen atmospheres using liquid nitrogen to reduce oxygen level. The container is insulated and equipped with a refrigeration unit to control temperature. A supply of liquid nitrogen is carried in a portable Linde LS-160B container (Figure 1) with automatic operation of the N_2 flow provided by the special controls. The oxygen level was set at 5 percent and the tomatoes were tested at weekly intervals for the following:

1. Overall quality - Subjective test for color, odor, flavor, texture and appearance.

2. Edible yield - Weight of uninfected tomatoes (wholesome tomatoes fit to eat) divided by the original weight to obtain percent edible yield.

3. Color - By subjective means (appearance to the naked eye using an experienced panel of 10 technologists using a scale ranging from 9 (excellent) to 1 (extremely poor), and by objective means using Hunter Color and Color Difference Meter measuring red color on whole tomatoes at the blossom end as well as at the stem end, and on the interior by cutting the tomato in halves.

4. Texture - By subjective means to determine softness or firmness by feel, and by objective means using Hunter Spring Mechanical Force Gauge.

Oxygen levels were monitored during the experiments. A representative sample of the atmosphere in the controlled atmosphere container was analyzed gas chromatographically at weekly intervals. After the sample was taken, the container door was opened for a few minutes to check the voltage of the oxygen analyzer/controller.

In each experiment U.S. No. 1 Grade tomatoes ranging in color from number 2 (Breakers) to number 3 (Turning) as described in Federal specification HHH-T-576f, Tomatoes, Fresh, were purchased from the local market. All tomatoes were Los Angeles

*Oxytrol is a registered trademark of Occidental Petroleum Corporation.

Lug size 6x7 (2-4/16"-2-10/16"). Tomatoes were contained in 10 lb. monolayer fiber boxes with lids (35-40 tomatoes per box). Each tomato was held in a separate paper cup to prevent any contact between neighboring fruits.

Twenty boxes of tomatoes for each experiment were randomly divided into 4 equal lots. Each lot containing 4 boxes were treated as follows:

Lot 1: The tomatoes were dipped in 20 ppm Oxine* (Chlorine dioxide) solution for 3 minutes, drained for 5 minutes and placed back in the boxes. The boxes were then placed in the controlled atmosphere container under 4-5 percent oxygen.

Lot 2: The tomatoes were treated as above and then placed in a similar size container operating under normal atmosphere.

Lot 3: Control tomatoes with no chlorine dioxide treatment stored in the same container with lot 1.

Lot 4: Control tomatoes with no chlorine dioxide treatment stored in the same container with lot 2.

A perforated paper bag containing two pounds of quick lime was placed in each container to scrub the CO_2 during storage. The temperature of each container was maintained from 50 to 55°F.

*Oxine is a registered trademark of Lily Products Co., Glendale, Arizona.

RESULTS AND DISCUSSION

Results of experiments conducted on the storage of 3 different tomato crops for periods up to 8 weeks are shown in Tables 1 thru 5. Table 1 shows that tomatoes treated with chlorine dioxide exhibited higher edible yields than the untreated ones upon storage at 50-55°F. for 4 or 6 weeks regardless of the atmosphere. Furthermore, tomatoes stored under low oxygen showed significantly higher edible yields than tomatoes stored under normal atmosphere with or without the chlorine dioxide treatment. However, tomatoes dipped in chlorine dioxide solution and then stored under low oxygen showed the highest edible yield compared to either treatment above.

Results shown in Table 2 indicate that tomatoes stored under low oxygen exhibit a significantly higher edible yield than those stored under normal atmosphere. The difference in edible yield increased during storage. Furthermore, when all tomatoes after 6 weeks were transferred to a conventional walk-in refrigerator at 40°F. and kept there for additional two weeks, the tomatoes which were previously stored under low oxygen continued to show significantly higher edible yields than those previously stored under normal atmosphere.

Visual examination of tomatoes suggested that black spot type rot similar to Alternaria, Buckeye, Anthracnose and others as well as Rhizopus and other fungal diseases were predominant in tomatoes stored under normal atmosphere, thus causing heavy spoilage.

Tomato firmness decreased significantly as storage time increased (Table 3). There was no significant difference in texture between 40° and 50°F. storage, or between low oxygen and air storage.

The Hunter Spring Mechanical Force Gauge readings (as objective measures for texture) obtained when applied on tomatoes at the stem end, blossom end or the sides of the fruits were not significantly different. However, differences were significant between tomatoes tested with and without the skin. Texture differences detected by the technological panel were not significant (Table 5). The skin color of tomatoes stored at 40°F. under normal atmosphere did not undergo significant changes. Tannish-yellow was predominant, ranging between No. 2 (Turning: 10-30 percent of the surface showing a definite change in color to tannish-yellow, pink, red, or combination) and No. 3 (Turning: approximately 30 percent tannish-yellow, pink, red, or combination). Tomatoes stored at 50-55°F. gradually developed a red color and at the end of 4 weeks storage 60 to 90 percent of the surface area showed a pinkish-red or red color. However, the color was deeper and more uniform in tomatoes stored under low oxygen and was significantly preferred by the technological panel to those stored under normal atmosphere (Table 5).

The red color significantly increased as the storage time increased (Table 4) when measured by the HCOCD meter. A significant color difference was found between measurements on a single fruit - made externally at the blossum end and the stem end, or internally when the fruit was cut in half.

The technological panel preferred the flavor of tomatoes stored at 50-55°F. under low oxygen compared to those stored under normal atmosphere at 50-55°F. or 4C°F. Flavor of the latter received the lowest ratings (Table 5).

It is concluded that controlled atmosphere storage at 50-55°F. significantly extended the shelf life of tomatoes. The shelf life was further enhanced upon treatment of tomatoes with chlorine dioxide prior to CA storage.

REFERENCES

1. Anonymous, 1968. Subsistence Guidance for overseas shipment of perishable items. Handbook 4235.4, Defense Personnel Support Center, Philadelphia, Pa.

2. Parsons, C.S. 1959. Extending the storage life of cabbage. celery, lettuce and tomatoes aboard a Navy Supply ship. USDA Marketing Research Report No. 336.

3. Heiligman, F. 1956. Evaluation of method for handling and shipping fresh tomatoes. R&D Associates Activities Report 8, (1), 67-70.

4. McColloch, L.P., and Worthington, J.T. 1952. Low temperature as a factor in the susceptibility of mature green tomatoes to alternaria rot. Phytopathology. 42 (8) 425-427.

5. Butler, E.E. 1960. Pathogenicity and taxonomy of geotrichum candidum. Phytopathology. 50, 665-672.

6. Gorfien, H., Rahman, A.R., Johnson, D.R. and Anderson, E.E. 1969. Effect of a controlled atmosphere system on the storage life of lettuce: Part I - Laboratory Tests. NLABS Technical Report 70-23-FL (FL-99).

7. Rahman, A.R., Schafer, G., Taylor, G.R. and Westcott, D. 1970. Storage life of lettuce as affected by controlled atmosphere system. NLABS Technical Report 70-48-FL (FL-106).

8. Stewart, J.K., Ceponis, J.J. and Berha, L. 1970. Modified atmosphere effects on market quality of lettuce shipped by rail. U.S. Dept. Agr. Market Research Report No. 863.

9. Lipton, W.J. 1971. Controlled atmosphere effects on lettuce quality in simulated export shipments. U.S. Dept. Agr., Agr. Res. Serv., Hyattsville, MD. ARS 51-55.

10. Lockhart, C.L., and Eaves, C.A. 1962. An evaluation of captan smoke generators for controlling rots in stored tomatoes. Can. J. Plant Sci. 42 (2),, 294-302.

11. Parsons, C.S., and Anderson, R.E. 1970. Progress on controlled atmosphere storage of tomatoes, peaches, and nectarines in "1970 Yearbook" United Fresh Fruits and Vegetable Association, pp 175-182. Washington, D.C.

12. Gorfien, H., Rahman, A.R., Taylor, G. and Westcott, D.E. 1970. Controlled atmosphere systems laboratory studies in tomatoes. NLABS Technical Report 70-58-FL (FL-108).

13. Tolle, W.E. 1969. Hypoheric storage of mature green tomatoes. Marketing Research Report #842 - USDA, Washington, D.C.

14. Salunkhe, D.K. and Norton, R.A. 1960. Prepackaging treatments extend storage life of fruit. Utah Agr. Exp. St. Farm and Home Sci Bull. No. 21.

15. Watada, A.E., Morris, L.L. and Rapport, L. 1964. Modified atmosphere effects on lettuce. Fruit and vegetable perishables. Handling conference Proc. Univ. California, Davis, California.

16. El-Mansy, H.I., Salunkhe, D.K., Hurst, R.L. and Walker, D.R. 1967. Effects of pre and post-harvest applications of 6-furfurylamino--purine and N - benzyladenine on physiological and chemical changes in lettuce. Hort. Res. 7:81-89.

17. Singh, B., Littlefield, N.A. and Salunkhe, D.K. 1970. Effect of CA storage on amino acids, sugar, and rate of respiration of "Lambert" sweet cherry fruit. J. Am. Soc. Hort. Sci. 95: 458-461.

18. Magoon, C.E., 1969. Tomatoes, "Fruit and Vegetable facts and pointers". pp. 1-43. United Fresh Fruit and Vegetable Association, Washington, D.C.

19. Mc Colloch, L.P., Cook, H.T. and Wright, W.K. 1968. Market disease of tomatoes, peppers and eggplant. Handbook #28, USDA Washington, D.C.

20. Hall, C.B., 1963. Effect of storage temperature after ripening on the color, firmness and placental breakdown of some tomato varieties. Fla. State Hort. Soc. 76, 304-307.

21. Rahman, A.R. and Westcott, D.E. 1970. Quality of lettuce as affected by refrigeration and controlled atmosphere systems during transportation. NLABS Technical Report 71-10-FL (FL-114).

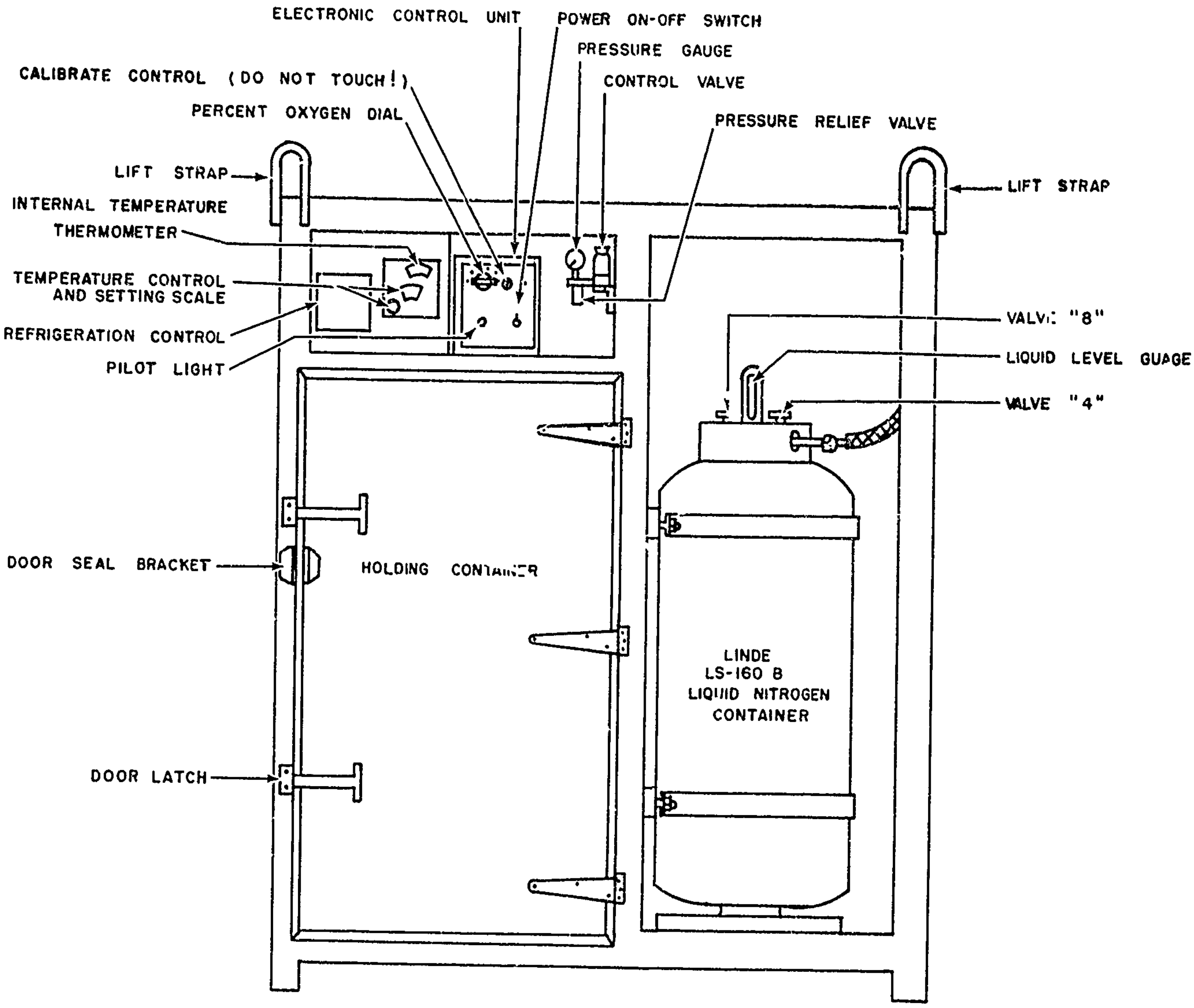

FIGURE I

FRONT VIEW-OXYTROL MODEL 050 PORTABLE CONTAINER-
OPERATING CONTROLS

Table 1 - Effect of Chlorine dioxide and CA on Edible Yield of Tomatoes at 50-55°F.

% Edible Yield

Crops	4 Weeks				6 Weeks			
	Air		5% O_2		Air		5% O_2	
	ClO_2	Control	ClO_2	Control	ClO_2	Control	ClO_2	Control
Crop 1	67.3	61.2	82.9	74.0	51.2	40.3	69.8	59.7
Crop 2	65.2	58.4	81.2	71.9	49.2	56.3	70.2	63.1
Crop 3	59.8	53.6	79.8	70.2	52.1	43.7	70.3	64.4

* Significant at the 1 percent level (CA vs. normal atmosphere and chlorine dioxide vs. control)

Table 2 - Effect of CA on Edible Yield of Tomatoes at 50-55°F.

	% Edible Yield						
	Weeks of storage at 50 to 55°F.					Additional 2 weeks storage at 40°F. in normal atmosphere	
Atmosphere	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks
CA*	89.2	85.6	75.3	68.8	64.9	50.6	42.3
Normal	82.6	74.2	65.3	51.8	44.8	29.8	10.5
CA**	84.6	80.8	73.4	68.9	60.3	52.3	43.2
Normal	78.3	72.2	63.1	62.4	54.5	43.1	19.5
CA**	91.4	83.4	75.3	70.2	61.8	50.2	40.8
Normal	84.2	72.3	55.8	44.8	35.7	28.1	15.6

* Significant at the 1 percent level (CA vs. normal temperature)

Table 3 - Effect of Storage Conditions on Texture of Tomatoes

	Initial pressure in lbs			1 Week* pressure in lbs			2 Weeks* pressure in lbs			3 Weeks* pressure in lbs			4 Weeks* pressure in lbs			5 Weeks* pressure in lbs		
Initial	B. end	S. end	Side	B. end	S. end	Side	B. end	S. end	Side	B. end	S. end	Side	B. end	S. end	Side	B. end	S. end	Side
with skin	7.8	4.9	6.3															
without skin	4.9	2.5	3.6															
40^{o}F. Normal atmosphere																		
with skin**				3.0	5.5	3.3	2.2	2.7	2.5	1.5	1.2	1.6	1.3	1.8	1.8	0.7	0.5	0.7
without skin				2.2	3.8	2.8	1.3	0.9	0.6	1.0	0.9	1.2	1.0	0.7	0.6	0.3	0.2	0.5
50^{o} at 5% O_2																		
with skin				3.1	3.0	2.3	2.8	1.8	3.1	1.7	1.3	1.4	1.4	1.5	1.8	1.5	1.3	1.7
without skin				0.5	1.8	1.0	1.8	0.7	1.4	0.8	0.4	0.5	0.6	0.6	0.7	0.8	1.0	1.1
50^{o} Normal atmosphere																		
with skin				2.5	4.0	3.1	2.2	2.8	2.4	2.0	1.5	1.7	1.5	1.8	1.5	1.2	1.3	1.7
without skin				1.1	2.3	1.2	1.2	0.7	0.6	0.9	0.5	1.1	0.7	0.5	0.6	0.4	0.6	1.0

B = Blossom end
S = Stem end

* Significant at the 1 percent level (time of storage in weeks)
** Significant at the 1 percent level (with skin vs. without skin)

Table 4 - a_b Value of the Hunter Color and Color Difference Meter of Tomatoes During Storage

Storage Condtions	Exterior Blossom end (bottom)*	Exterior Stem end (top)*	Interior Tomato (cut in half)*	Time of Storage
	17.2	4.0	7.8	initial
CA 5% O_2 at 50-55°F.	21.4	23.6	14.9	1 week**
Normal atmosphere at 50-55°F.	25.7	28.3	17.6	
Normal atmosphere at 40°F.	21.0	12.6	18.7	
CA 5% O_2 at 50-55°F.	23.1	24.4	18.7	
Normal atmosphere at 50-55°F.	29.6	23.9	21.6	2 weeks**
Normal atmosphere at 40°F.	18.1	11.7	12.7	
CA 5% O_2 at 50-55°F.	23.1	26.2	27.3	
Normal atmosphere at 50-55°F.	29.3	29.0	26.2	3 weeks**
Normal atmosphere at 40°F.	25.2	19.3	14.8	
CA 5% O_2 at 50-55°F.	29.9	27.4	27.1	
Normal atmosphere at 50-55°F.	32.7	30.3	24.4	4 weeks**
Normal atmosphere at 40°F.	24.3	16.4	17.8	

* Significantly different at the 1 percent level (position of color measurement)
** Significantly different at the 1 percent level (time of storage in weeks)

Table 5 - Average Ratings of Technological Panel on Tomato Quality as Affected by Storage Conditions

	Color*					Flavor*					Texture				
Weeks	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
CA 5% O_2 at 50-55°F.	7.0	7.0	7.0	6.5	6.7	6.6	6.6	6.6	5.7	5.5	6.4	6.7	6.8	6.5	5.9
Normal atmosphere at 50 to 55°F.	6.7	5.9	6.2	6.2	6.4	6.3	4.4	4.8	3.7	4.5	6.5	5.7	5.2	6.0	6.1
Normal atmosphere at 40°F.	4.4	4.7	3.8	4.3	5.0	5.1	5.2	4.3	4.6	5.0	5.0	6.0	5.9	6.1	6.2

* Significant at the 1 percent level (CA vs. normal atmosphere at 50-55°or 40°F.)